# CHANGING THE ECONOMIC LANDSCAPE:

# THE PHENOMENON OF REGIONAL INVERSION

# IN THE US MANUFACTURE SECTOR


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**ABSTRACT**

Regional Inversion is the name that is been given to the phenomenon whereby the traditional industrial areas of certain countries lose their weight in favor of what were formerly peripheral zones. Against this background, the first objective of this paper is to offer a formal and rigorous definition of the concept of Regional Inversion from an econometric point of view. To that end, we relate such a process with the long-run concepts of Convergence and Catching-Up. Secondly, we test this definition through the use of the unit root statistics, and apply such statistics in order to demonstrate the presence of this phenomenon in some of the US two-digit SIC industries.

**Keywords**: Regional Inversion; US manufacture sector; unit root tests; structural breaks

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## 1.- Introduction

During the course of the 1990s, the contributions of authors such as Krugman (1991), Fujita, Krugman, and Venables (1999) or Puga (1999) have given rise to the appearance, or perhaps more accurately, to the rediscovery of a literature which has been given the title of Economic Geography. This discipline is understood as the study of the location of economic activity in space. All these papers, which are of a theoretical character, illustrate the importance that the interdependent action of certain elements has in explaining the appearance of industrial complexes, where manufacturing production is concentrated in a particularly significant form. As examples of such elements, we can cite the externalities of demand, the input-output linkages between companies, the existence of increasing returns or the consideration of transport costs. The core message of these paper is that the industrial economic landscape of the majority of countries is not entirely homogenous, with the frequent appearance of industrial belts that monopolize a significant part of output.

One of the better examples of an industrial belt, given that it corresponds to the leading manufacturing power in the world, is that located in the United States. This belt appeared in the last third of XIX century and, in general terms, maintained its status as the industrial nucleus of North America until World War II[1]. Geographically (see, for example, Stut and de Souza, 1998) it is located in the Northeast of the country and includes the states belonging to the regions of New England, the Mid East, and the Great Lakes, forming what has come to be described as "Snow Belt" or "Frost Belt".

Industrial belts in general, and that of the USA in particular, have not been immune to the great transformation that has taken place in the sectoral distribution of labor in the developed countries during the last few decades. This process has brought with it remarkable implications for the spatial location of the population, and has also had consequences in both the economic and political environments. Thus, concentrating again on the US case, we can observe that although industrial employment has remained relatively stable[2] in absolute terms, at around 23-24 million between 1970 and 1995, its percentage participation has suffered a dramatic and rapid fall, from 24.3% of employment in 1972 to 19.8% in 1983 and 17% in 1992 (data taken from Hayter, 1997), with this decline being the result of the remarkable growth in the service sector of the economy.

Having said that, and as Blanchard and Katz (1992) and, particularly, Suárez-Villa (1992) have indicated, an essential characteristic of this phenomenon is that it has not affected all the zones in the same way. We can speak, therefore, of important regional performance disparities, in the sense that the deterioration in manufacturing employment has been more acute in some states that in others. Indeed, in some of them there has been a move against the general tendency and industrial employment has actually increased. That is to say, the increase in the weight of the service sector and the decline in that of the primary sector have been common elements in all the zones, albeit with a greater or lesser intensity. However, this cannot be said with respect to the industry sector, whose decline has essentially been a regional problem.

Against this background, it is interesting to examine what have been the main space changes that the US industrial sector has undergone in, for example, the last thirty years. There is a certain degree of consensus, guaranteed by the data, (Norton, 1990, Suárez-Villa, 1992, Suárez-Villa and Cuadrado-Roura, 1993, Fan and Casetti, 1994,

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[1] The genesis and evolution of the American industrial belt is described in Fogel and Engerman (1971) or, more recently, in Kim (1995).

[2] In absolute terms, the industrial employment in the developed countries has reamined constant or has experienced a slight decreasing tendency in the last decades (United Kingdom. Germany, Canada, Australia). The only exception is represented by the case of Japan, where industrial employment has increased appreciably in absolute values.

Hayter, 1997) that the industrial employment tendency in the USA is part of a more general shift away from Northeast and Midwest "Frost Belt" in favor of the Southern and Western "Sun Belt". Here we should note that, whilst the "Frost Belt" corresponds to the traditional American industrial belt, the "Sun Belt" can incorporate a variety of different states. However, in this work we will consider that it is made-up of the three more emerging states, namely California, Florida and Texas, an approach that has already been adopted in Suárez-Villa (1992)[3].

Although we will consider this aspect in greater detail in the following Section, at this point it suffices to say that Regional Inversion (hereafter RI) is understood as the flow of capital, firms and population from what was once the industrial nucleus (the Frost Belt) to the new manufacturing areas (the Sun Belt).

In addition to the earlier-mentioned space evolution, another characteristic of the US manufacture sector upon which emphasis should be placed is the different pattern of behavior followed according to the sub-sector being considered. In effect, as Stevens and Treyz (1986) indicated, the distinct evolution of industrial employment by zones is explained by reference to the different regional industrial mix found within them. Thus, the states that have a higher degree of specialization in traditional manufacturing sectors experience more marked falls than those whose industrial sector is made-up to a greater extent of industries which are linked more closely to the expanding services sector or high-tech industries. Such a relationship can be explained by the fact that the invention and innovation component is more important at the micro level in the latter. It therefore makes sense to analyze the RI phenomenon not from a perspective that considers the aggregate manufactures, but from one that distinguishes between different industrial

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[3] As support for this decision, it suffices to say that from 1980 to 1990 the North American population grew by 22 million people, of which 12, 55%, went to the zone formed by California, Florida and Texas (taken from Norton, 1990)

subsectors[4], since it is possible to foresee that the different forms of behavior cannot be reduced to a single pattern.

In this context, and with particular reference to the geographical changes undergone by the US industrial sector from the end of the 1960s, this paper has a dual objective. First, to provide the RI phenomenon with a conceptual framework and, more specifically, with a rigorous econometric definition which allows us to simultaneously relate and differentiate it from other relatively compatible concepts, such as Convergence or Catching-Up. Secondly, and having satisfied this objective, to carry out an empirical application that identifies those US manufacture sub-sectors in which it can be statistically accepted that RI has taken place. In our view, providing an answer to this question can clearly be useful when seeking to anticipate the future regional evolution of the US industrial sector.

The results of this empirical exercise show that the RI phenomenon has taken place in a significant number of U.S. two-digit SIC industries. In particular, in eleven of the twenty manufacture sub-sectors analyzed, we can accept that this type of reversal has indeed taken place. Such a finding illustrates that we are considering a sectoral problem which, as already mentioned, does not affect all the manufactures in a homogenous form.

The rest of the paper is organized as follows. In Section 2 we provide a more detailed description of what we understand by RI and the factors that have led to its appearance in certain US industries. Section 3 considers the problem from an econometric point of view and defines the situations in which we can statistically admit that the RI phenomenon is present in a given manufacturing sub-sector. In Section 4 we report the results of an empirical application carried out in the light of the contents of

[4] Specifically, in the empirical application we have considered the 20 subsectors that are generated when taking a disaggregation up to two-digit SIC industries.

the preceding Sections. Finally, Section 5 closes the paper with a review of the main conclusions.

## 2.- Regional Inversion: Its concept and its causes in the US manufacture sector

To the best of our knowledge, the expression "Regional Inversion" has its origin in Suárez-Villa (1992) and was once again used in Suárez-Villa and Cuadrado-Roura (1993). Nevertheless, the underlying concept has been employed by a variety of authors who either do not propose a specific terminology, or adopt an alternative one (for example, Fan and Casetti, 1994, who speak of " Polarization Reversals ").

In this paper, we understand that RI takes place in an industry when there is (ALGO FALTA)"an emergence of previously peripheral regions, and their prospects for passing the traditional heartland areas" (Suárez-Villa and Cuadrado-Roura, 1993). It is, therefore, a sectoral phenomenon, in which two zones – the core and the periphery - tend to interchange their roles. Thus, in a given industry, the once dominant zone loses weight in the geographical area of reference being considered - in our case the U.S. -, in favor of a new area that increases its share. Of course, it should be noted that if at some particular moment in time the importance of the old periphery strictly surpasses that of the nucleus, then RI takes place, with this being a sufficient condition. However, it is enough (see the following Section for a more rigorous discussion) for the difference in the participation of both zones in the sector to present a decreasing tendency, without it being strictly necessary that there is an overturning of the predominance. In other words, the disparities between the peripheral regions and the core areas of each nation tend to be reduced, thus acting as an important equalizing factor. Further note that, since we are dealing with percentages of employment of each zone in an industry with respect to the total of the country, it is highly improbable that both series will simultaneously present increasing or decreasing tendencies. If this in fact happen, it would be indicating that we have erroneously chosen what initially constituted the nucleus or the periphery.

The RI phenomenon has taken place in a number of developed countries (United Kingdom, Germany, Spain), albeit with differing degrees of intensity. However, it is in the U.S. where the clearest example can be found, favored by the limited presence of barriers to labor mobility. Let us briefly consider some of the most important causes than have helped to the appearance of this phenomenon in certain industries within the USA.

In general, the labor force in the Sun Belt offers a lower percentage of trade union membership and it is also cheaper to employ, with this latter aspect being more significant if the life cycle of the product is in its mature phase. Similarly, the proximity to Mexico and the extension of the NAFTA to the South has favored the creation of “twin plants” in the border states. Furthermore, the improvements to the transport infrastructure in the hinterland and the development of the dematerialized economy (Quah, 1996) have allowed for easy access to formerly peripheral areas. The existence of a lower tax burden in the South and the West of the US can represent another factor (Chinitz, 1986). The changes that have taken place in the organization of manufacturing production (computerized production and “just in time”), that reduce the minimum efficient scale and the weight of the agglomeration economies, thereby facilitating the appearance of "new industrial spaces", have also played a role. Mention should also be made of attractive climate and amenities enjoyed by the Sun Belt (Bourne, 1980). Finally, Suárez-Villa (1989) maintains that the latest tendencies of manufacturing location, essentially with respect to high-tech and innovative industries, occur in the sub-centers of polycentric cities, an urban phenomenon that has found greater diffusion in the Sun Belt.

All these elements, which are interdependent, must be understood within the more general framework defined in the previous Section, namely that there has been an increase in the weight of the tertiary sector that has favored the appearance of dynamic shifts towards service-driven manufacturing, to the detriment of more traditional manufacturing sub-sectors. Again, the diverse regional industrial mix, referred to earlier, has been a key factor in explaining the selective regional growth of the different manufactures.

## 3.- Regional Inversion from an econometric point of view

In this Section, our aim is to propose a formal definition of the RI concept, one which can subsequently be tested with econometric tools. To that end, let us assume that the population of a country may be divided into n geographical zones, such that $P_i$ denotes the value of a generic economic variable P in the zone i, where i = 1, 2,...n. Let us further assume that these series satisfy the following restriction:

$$a_i(L)P_{i,t} = \mu_i + u_{i,t} \qquad i = 1, 2, ..., n, \qquad t = 1, 2, ..., T \qquad [1]$$

where $a_i(L)$ is the i-th lag polynomial, so that only one of its roots is on the circle unit and $u_{i,t}$ is any stationary and invertible ARMA process.

Under these circumstances, we want to characterize the relationship, with regards to the economic variable P, that exists between the two regions, say regions 1 and 2 and where, for the sake of simplicity, we assume that $P_{1,t} > P_{2,t}$. Thus, we should first bear in mind the papers of Bernard and Durlauf (1995, 1997). These authors, adopting the perspective of the neo-classical growth model, consider that the relationship between the economic variables[5] can respond to two different patterns of behavior. On the one hand, it is possible for these variables to tend together towards a common value, which would describe a catching-up process. On the other, it is also possible that the long-run forecasts of these series coincide at a fixed time t; in this latter case, both series converge.

If we extrapolate these two definitions to our current case, we can consider that $P_1$ and $P_2$ converge, whenever it holds that:

$$\lim_{k\to\infty} E\left[P_{1,t+k} - P_{2,t+k} / I_t\right] = 0 \qquad [2]$$

where $I_t$ denotes all the information available up to period t. As we can see, the long-run predictions for variables $P_{1,t}$ and $P_{2,t}$ are identical. Thus, under these circumstances, both of them will take the same value in the infinite and we can speak of a convergence process. Consequently, a method for proving the presence of a long-run convergence process is to show that the deviation of $P_{1,t}$ from $P_{2,t}$ is a zero mean stationary process, which can easily be carried out by way of the unit-roots/cointegration techniques.

This long-run convergence process does not admit the presence of any deterministic element in the relationship between $P_{1,t}$ and $P_{2,t}$. This is a very strong assumption, which is not habitually satisfied in empirical studies. Thus, it seems appropriate to relax this assumption, and to define a weaker concept of convergence which allows for the presence of a trend in the ($P_{1,t}$-$P_{2,t}$) relationship. Therefore, we can admit the presence of a catching-up process between the periods t and t+k whenever it is true that:

[5] In particular, and as is habitual in the literature, the concepts of convergence and catching-up are applied to the growth rates of the countries, so that the generic variable P is usually the per capita income of each region. Nevertheless, their definitions are potentially valid for any other type of variable.

$$\lim_{k \to \infty} E\left\lfloor P_{1,t+k} - P_{2,t+k} / I_t \right\rfloor < P_{1,t} - P_{2,t} \qquad [3]$$

We can now observe that the difference between $P_{1,t}$ and $P_{2,t}$ may not disappear even in the infinite, although is continuously decreasing. Once again, a method for showing the presence of a catching-up process is to verify that the deviation of $P_{1,t}$ from $P_{2,t}$ exhibits a long-run relationship around a deterministic trend, whose parameter takes a negative value.

Given that these concepts are used to develop the relationship between two (or more) economic series, some issues are implicitly considered in the previous definitions. First, both $P_1$ and $P_2$ are expected to increase across the sample size, since they usually refer to per capita income or output per worker. Therefore, it is implicitly assumed that $\mu_i > 0$ (i = 1, 2) in [1]. Secondly, a strict definition of catching-up implies that the two output series tends to coincide in the long-run, without an overturning being produced between them. Thus, it would be more correct to re-define the catching-up equation as follows:

$$0 \leq \lim_{k \to \infty} E\left\lfloor P_{1,t+k} - P_{2,t+k} / I_t \right\rfloor < P_{1,t} - P_{2,t} \qquad [4]$$

thereby reflecting the catching-up relationship between $P_{1,t}$, and $P_{2,t}$ in a better form than in [3].

The two previous definitions of convergence and catching-up are useful, and indeed have been extensively used in the empirical literature to analyze the joint behavior of series related to the growth of OECD countries. However, they are not appropriate to explain the RI phenomenon that, by definition, considers variables of different characteristics than those used in the catching-up studies.

Thus, according to the concept introduced in the previous Section, RI exists when the differences in the sectoral percentage of employment of the regions, with respect to a broader zone of reference, tend to be reduced in time. If the selection of the two zones is correct, that is to say, an old core that loses importance and an emergent periphery, then the series associated with the latter is increasing, whilst the other will be constant or, more probably, decreasing. Therefore, the previous definitions are, strictly speaking, no longer valid, in that the parameter $\mu_i$ in [1] can now take negative values, reflecting the decrease in the percentage of the population of region 1 which is absorbed by region 2. Secondly, there is neither catching-up nor convergence whenever $\lim_{k \to \infty} E\lfloor P_{1,t+k} - P_{2,t+k} / I_t \rfloor$ can take negative values. In order to see this, let us now consider that the evolution of the series may not stop when $P_{2,t}$ crosses $P_{1,t}$, but rather may continue its increase, moving further away from $P_{1,t}$ and exceeding it.

We have verified that the concepts defined in the literature with respect to the convergence process are not able to capture all the possibilities of the relationship between the labor forces of two regions of a country. Thus, it is interesting to provide a more rigorous definition of these new concepts, in order for them to be tested later in the paper.

**Definition 1.** *Let $P_{1,t}$ and $P_{2,t}$ denote the percentage of sectoral employment of regions 1 and 2 at period t, such that both of them are generated by model [1], where we assume that $m_1<0$ and $m_2>0$, and further that $P_{1,t}> P_{2,t}$. Thus, there is a Weak Regional Inversion process between regions 1 and 2 across period t to period t+k, whenever it holds that*

$$0 \leq \lim_{k \to \infty} E\lfloor P_{1,t+k} - P_{2,t+k} / I_t \rfloor < P_{1,t} - P_{2,t} \qquad [5]$$

This first concept is qualitatively similar to that used in growth theory when defining the catching-up process. The main difference between the two is that we are now assuming that the percentage of sectoral employment of region 1 does not increase, but rather decreases. At the same time, this loss is absorbed (totally or partially) by region 2. In order to illustrate this concept, let us consider Figure 1. Here, we can observe that $P_{1,t}$ and $P_{2,t}$ show inverse trends, but that they do not cross each other. However, if this process were to continue into the future, both variables might indeed cross each other. In this case, we would be faced with a stronger concept of RI, which can be defined as follows.

**Definition 2.** *Let $P_{1,t}$ and $P_{2,t}$ denote the percentage of sectoral employment of regions 1 and 2 at period t, such that both of them are generated by model [1], where we assume that $m_1<0$ and $m_2>0$, and further that $P_{1,t} > P_{2,t}$. Thus, there is a Strong Regional Inversion process between regions 1 and 2 across period t to period t+k, whenever it holds that:*

$$0 < \lim_{k\to\infty} E\left[P_{2,t+k} - P_{1,t+k} / I_t\right] < P_{1,t} - P_{2,t} \qquad [6]$$

This case implies a stronger assumption than that considered in Definition 1. Now, it is necessary that the deviation between $P_{1,t}$ and $P_{2,t}$ changes its sign (note that Definition 2 involves the restriction $P_{2,t+k} - P_{1,t+k} < P_{1,t} – P_{2,t}$). At the end of this process, $P_{2,t}$ becomes larger than $P_{1,t}$ and, therefore, region 2 is the core region, whilst region 1 is now the periphery. We can observe this phenomenon in Figure 2 where, unlike in Figure 1, $P_{1,t}$ and $P_{2,t}$ now cross each other. However, we may consider that this is not the end of the process, but rather that the difference between $P_{2,t}$ and $P_{1,t}$ becomes even greater. We consider this situation in the following definition.

**Definition 3.** *Let $P_{1,t}$ and $P_{2,t}$ denote the percentage of sectoral employment of regions 1 and 2 at period t, such that both of them are generated by model [1], where we assume that $m_1<0$ and $m_2>0$, and further that $P_{1,t}> P_{2,t}$. Thus, there is an Absolute Regional Inversion process between regions 1 and 2 across period t to period t+k, whenever it holds that:*

$$\lim_{k\to\infty} E\left[P_{2,t+k} - P_{1,t+k} / I_t\right] \geq P_{1,t} - P_{2,t} \qquad [7]$$

The main difference between the concept of Absolute Regional Inversion and that considered previously lies in the fact that whilst $P_{2,t}$ crosses $P_{1,t}$ as in Definition 2, the final divergence between both series is greater or equal than that which existed at the beginning of the period. Thus, there has been a complete reversion: the initial core is now the periphery (as in the Strong Regional Inversion case) but, furthermore, the final difference between the core and the periphery is greater or equal to that which existed at the beginning. This concept is illustrated in Figure 3.

## 4.- Empirical Illustration

Having defined the different concepts of RI, this Section is devoted to their empirical illustration, with the exercise being based on the study of the RI process in the US manufacture sector. To that end, we first describe the data employed and, subsequently, report the main results that have been obtained.

### 4.1.- Data Base description

We have used the data reported in the Regional Economic Data Tables, published by the U.S. Federal Government, Bureau of Economic Analysis. The sample size covers the period 1969-1995. The disaggregation level in the manufacturing sector reaches up to two-digit SIC industries. Thus, we have considered the following 20 manufacture sectors: Food and kindred products (20), Tobacco products (21), Textile mill products (22), Apparel and other textile products (23), Lumber and wood products (24), Furniture and fixtures (25), Paper and allied products (26), Printing and publishing (27), Chemicals and allied products (28), Petroleum and coal products (29), Rubber and miscellaneous plastics (30), Leather and leather products (31), Stone, clay, and glass products (32), Primary metal industries (33), Fabricated metal products (34), Industrial machinery and equipment (35), Electronic and other electric equipment (36), Transportation equipment (37), Instruments and related products (38), and Miscellaneous manufacturing industries (39), with the SIC digit being reported in parenthesis.

The states that form the "Frost Belt" (FB) are those of New England, the Mid East and the Great Lakes areas. They define what has historically been the traditional industrial belt of the US: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Illinois, Indiana, Michigan, Ohio, and Wisconsin. This zone, which one time almost exclusively represented the US industrial core, is now being confronted with the emergent "Sun Belt" (SB), which was formerly considered as being the periphery. In this paper, and as has been mentioned earlier, we consider the SB to be formed by the following three states: California, Texas and Florida. Although there are significant differences between the number of States included in the FB and in SB, we should nevertheless note that these two regions are much more homogeneous with respect to their area and population[6], thereby allowing for comparisons to be made between them.

### 4.2.- Regional Inversion in the US manufacture sector

Let us illustrate the different concepts of RI by studying this phenomenon with respect to the US manufacture industry. According to the formal definitions of these concepts provided in Section 3, in order to prove the existence of any kind of RI process, we should simply analyze the time properties of the ratio formed by the percentage of employment in the two regions. As is habitual, we have taken natural logarithms. Thus, these ratios can be expressed as $Y_{it} = \ln(FB_{it}/SB_{it})$ where $FB_{it}$ represents the percentage of employment in the Frost Belt for Sector i at period t, whilst $SB_{it}$ is the percentage of employment in Sun Belt for Sector i at period t. If we can prove that ratio $Y_{it}$ is stationary around a deterministic decreasing trend, then we find evidence in favor of the presence of an RI process for sector i; if otherwise is the case, then we should conclude that there is no such evidence.

Before computing the unit root statistics, let us first offer a graphic analysis of the percentage employment evolution for the different sectors under consideration. These figures are jointly reported in Figure 4. Our starting hypothesis is that there has been a transfer between the employment of the FB and the SB. As we can see, the percentage of employment is always greater in the FB at the beginning of the sample, with this being the case for all the sectors. Furthermore, most of the figures show that the FB sectors present a decrease, whilst those of the SB exhibit an increase. We should

[6] The surface area of the FB is some 1,112,633 square kilometers, as compared to the 1,253,981 of the SB. As far as the population is concerned, the differences are a little more appreciable but, in any event, these are being quickly reduced. Thus, in 1970 the FB had 94.55 million inhabitants, whilst the SB had 40.15%, that is to say, 37.96 million inhabitants. In 1990, 98.87 million people lived in the FB and 59.68 million in the SB, representing some 60.36%.

also note that the percentage of employment of the SB is greater than that of the FB at the end of the sample for only one sector, namely Petroleum and coal products (29). All these preliminary results lead us to the conclusion that the US manufacture sector exhibits the necessary conditions for the existence of some kind of RI in some industries. More precisely, the Weak Regional Inversion concept would appear to be an appropriate starting hypothesis for most of the sectors, whilst the presence of either a Strong or an Absolute Regional Inversion process is not substantially justified by our data sample.

In spite of these apparently positive results, we should bear in mind that they are not sufficient to admit the RI hypothesis in that, according to the concepts defined in Section 2, it is necessary for the percentage employment rate to exhibit a stationary pattern around a deterministic decreasing trend. Thus, it is necessary for us to carry out a statistical study of their time properties. In this regard, a first possibility would be to determine the presence of a co-integration relationship between the percentage of employment of the i-th sector in FB and its equivalent in SB. Another possibility, which is the one adopted here, is simply to test for the integration order of the resultant rate ($Y_{it}$). If we accept the unit root null hypothesis, then we can consider that there is no type of RI process; however, if we reject it, we can consider that the data support the presence of such a process.

We begin by testing the unit root null hypothesis through the use of the statistics proposed in Dickey and Fuller (1979). Given the characteristics of the rates being studied, it seems to be appropriate to test this hypothesis by way of the estimation of the following model:

$$y_t = \mu + \rho\, y_{t-1} + \beta\, t + \sum_{i=1}^{k} \phi_i\, \Delta y_{t-i} + u_t \qquad [8]$$

and later calculating the pseudo t-ratio for testing whether the autoregressive parameter is 1. We will refer to this statistic as $\tau_\tau$. We should note that several lags of the first difference of the variable being studied are included in [8] in order to correct the possible presence of an autocorrelation pattern in the model residuals. Although a number of methods for the selection of the lag truncation parameter are available to us, we have chosen to use the k(t) procedure recommended in Ng and Perron (1995). This method involves a general-to-specific strategy, starting with a predetermined value of the lag truncation parameter ($k_{max}$) and then testing the significance of the single coefficient associated to the last lag until a significant statistic is encountered. We have used $k_{max}$=5 and the single significance of the lags is analyzed by comparing their t-ratios with 1.65.

Table 1 reports the values of the $\tau_\tau$ statistic. As we can see, the unit root null hypothesis is only rejected for the Paper and allied products (26) and Leather and leather products (31) sectors. Furthermore, if we analyze the figures for these two sectors, we can see that the percentage of employment in the FB is always greater than in the SB. Thus, we can properly conclude that there has been a Weak Regional Inversion process in these two sectors. This implies that the distance in the percentage of employment has diminished, although the percentage of employment in the FB is always predominant for these sectors. We have not found evidence in favor of any of the RI cases discussed in Section 3 for the other sectors considered.

The results of this first analysis lead us to conclude that there has not been a clear RI process in the US manufacture sector, although we have found some evidence in favor of a Weak Regional Inversion process for the Leather and the Paper sectors. However, we should recall that the RI processes may be subjected to changes, in the sense that the speed of the process may not be constant, but rather may move more rapidly in some periods than in others.

In effect, the RI phenomenon is not, or does not have to be, a linear process that flows in a continuous and uninterrupted form. Rather, it can be subject to changes in its speed with respect to what has been its trajectory up to a certain moment in time and, consequently, the process can undergo some type of structural rupture in the course of its evolution. The consideration of such a possibility seems particularly appropriate for the US case. Thus, Chinitz (1986) speaks of the "resilience - of the North- in the face of strong trends favoring the South and West", when drawing attention to the remarkable recovery of manufacturing employment in New England. Note here that between 1975 and 1981 manufacturing employment grew by 10.7% in the U.S. and by no less than 17% in New England. Furthermore, the decline in FB is far from being a free fall; in this sense, Rowley et al. (1991) and Fan and Casetti (1994) defend the existence of a "bicoastal economy". Finally, Hayter (1997) observes that "since the early 1980s some observers have noted 'economic reversals' in the frostbelt-sunbelt trend". Consequently, it makes sense, from an econometric point of view, to test for the existence of RI in a given sector in a context in which structural breaks can occur.

In this regard, and apart from its inherent economic importance, the presence of discontinuities in the speed of RI also has serious consequences from the econometric point of view. Since the seminal paper of Perron (1989), it has been well accepted that the unit root tests may be distorted towards the acceptance of the unit root null hypothesis under those circumstances where a structural break is omitted in the empirical model. Consequently, if the RI process has not been produced in a continuos way, then the unit root statistics used earlier may lead us to wrongly accept the unit root hypothesis. Thus, it seems to be appropriate to consider those unit root statistics that tests for the unit root hypothesis allowing for the presence of a break in the DGP. Admitting that the variable being studied exhibits a trended behavior, and assuming that the break gradually affects the variable, Perron (1989) suggests estimating the following models:

$$y_t = \mu + \beta t + \gamma \, DT_t + \delta \cdot DU_t + \theta \cdot D(TB)_t + \rho \cdot y_{t-1} + \sum_{i=1}^{k} c_i \cdot \Delta y_{t-1} + \varepsilon_t \qquad [9]$$

$$y_t = \mu + \beta t + \delta \cdot DU_t + \theta \cdot D(TB)_t + \rho \cdot y_{t-1} + \sum_{i=1}^{k} c_i \cdot \Delta y_{t-1} + \varepsilon_t \qquad [10]$$

where $DU_t$ is a dummy variable that takes value 1 if $t>TB$ and 0 otherwise, with $TB = \lambda\ T$, $1> \lambda >0$ and $\lambda$ is the parameter that controls the period where the break appears. Similarly, $D(TB)_t$ is a pulse variable that takes the value 1 if $t = TB +1$ and 0 otherwise and $DT_t = t\ DU_t$. Model [9] implies a change in both the intercept and the slope of the model, whilst [10] considers that the break has only affected the intercept. Once we have estimated these two models, we should test for the unit root null hypothesis by way of the pseudo t-ratio. The distribution of this statistic depends on the value of the parameter $\lambda$. In order to solve this problem, we can adopt a general approach and allow the model to estimate the most feasible time of the break by way of the minimization of the pseudo t-ratio. However, Perron (1997) and Vogelsang and Perron (1998) have recently shown that the imposition of the restriction that the sign of the break magnitude is a priori known leads to an improvement in the properties of the unit root statistics. Therefore, we will adopt this restriction in the empirical analysis, selecting the time of the break by way of the maximization of the pseudo t-ratio related to the parameters that measure the magnitude of the break. This implies that we are including the a priori restriction that the break is associated to a deceleration in the RI process. This assumption is confirmed when no restriction is imposed on the sign of the break, with the results presented in Table 2 being almost unaltered.

The main results are reported in Table 2. Panel A of this Table documents the values of the pseudo t-ratio for testing whether the autoregressive parameter is 1 when the time of the break is selected via the maximization of the t-ratio of $\gamma$, that is to say, the parameter that measures the change in the slope. According to our data, we can reject the unit root null hypothesis for the following 8 Sectors: Food and kindred products (20), Furniture and fixtures (25), Chemicals and allied products (28), Petroleum and coal products (29), Rubber and miscellaneous plastics (30), Fabricated metal products (34), Industrial machinery and equipment (35), and Instruments and related products (38). We can admit that the ratio of the percentage of employment between the FB and the SB is stationary around a decreasing breaking trend. This implies accepting the presence of a Strong RI process for the Petroleum and coal products sector and a weak RI process for the rest. The inclusion of a breaking trend in the model specification indicates that the RI process has suffered a relative de-acceleration. For the majority of the industries, this break occurs around 1980, which coincides with the results reported previously in Chinitz (1986) and Hayter (1997). However, our results also show that the break may have occurred in the mid 1980s for the Fabricated metal products (34) and Instruments and related products (38) sectors.

On the other hand, Panel B of Table 2 reports the values of the statistics when it is considered that the break exclusively affects the intercept of the model. Here, we should note that, as was the case in Panel A, the time of the break has been selected by maximizing the value of the t-ratio associated to the parameter $\delta$. Under this assumption, we can find additional evidence in favor of the presence of a weak RI process in the following three sectors: Apparel and other textile products (23), Paper and allied products (26) and Leather and leather products (31). The estimated breaking times indicate that the change in the intercept occurred at the beginning of the 1980s for sectors 23 and 31, and in the mid-1980s for the Paper industry.

Finally, we have not found evidence of any kind of RI process for the following nine sectors: Tobacco products (21), Textile mill products (22), Lumber and wood products (24), Printing and publishing (27), Stone, clay, and glass products (32), Primary metal industries (33), Electronic and other electric equipment (36), Transportation equipment (37), and Miscellaneous manufacturing industries (39). This result should be interpreted with caution, given that the sample size considered in this paper is not particularly large and thus the information that it may provide is limited. Furthermore, we should be conscious of the well-known problem of power lack that the unit root statistics show, especially in small finite samples. Thus, it is possible that an increase in the available information may lead to a greater volume of evidence in favor of some kind of RI.

In summary, from a first reading of the results presented in Table 2, we can conclude that the RI phenomenon has taken place in a significant number of U.S. two-digit SIC industries. In particular, we can accept that this type of reversal has occurred in eleven of the twenty manufacturing sub-sectors under analysis. This shows that we are considering a sectoral problem, one that, as has already been mentioned, does not affect all manufactures in an homogenous form.

The incidence has been significantly greater in non-durable goods, where the existence of RI is not accepted in only three of the ten industries making up this group.

Furthermore, and as was to be expected, the industries most closely tied to natural resources, such as Tobacco products (21), Textile mill products (22), Lumber and wood products (24) and Stone, Clay, and glass products (32) have not experienced RI. The same happens with sectors that require a significant initial investment for their operation, which can act as a brake on its geographic mobility; from amongst such sectors, we can particularly cite Primary metal industries (33) and Transportation Equipment (37).

**5.- Conclusions**

In this paper we have analyzed a concept of Economic Geography which, in our opinion, is a particularly relevant one but which has not received sufficient attention, namely that of Regional Inversion. Under this phenomenon, which has affected a large number of developed countries, the traditional industrial areas lose weight for a variety of reasons in favor of certain formerly peripheral zones that emerge with some force in the industrial panorama.

The first objective of this paper is to equip the concept of Regional Inversion with a rigorous econometric content, so that it can subsequently be empirically tested for a given country. Whilst it is true that the notion of Regional Inversion is related to habitual concepts in the literature, such as those of Catching-Up and Convergence (see Bernard and Durlauf, 1995 and 1997), the contents of these concepts are not entirely similar. In this sense, Regional Inversion needs a specific definition, one that is proposed in this work. Also, and depending on the level that reaches the change, the terminology of Weak, Strong and Absolute Regional Inversion has been proposed out to characterize phenomena very related but that can present different intensities in the real world.

The second objective, that previously requires of a correct solution for the first, resides in contrasting empirically the existence or not of Regional Inversion for a assembly of industrial sectors. To do that, the manufacturing sector of U.S. has been chosen. And the selection is not accidental, since certain consensus exists with respect to that the industrial economic landscape of the United States has experienced strong space modifications in the last decades. However, most of the works are essentially descriptive, missing a rigorous econometric processing and conceptually well defined that responds to this question.

Thus, in the empirical application the 20 two-digit SIC industrial sectors are taken from 1969-1995. For each one of them it is contrasted statistically if a phenomenon of Regional Inversion from the denominated Frost Belt (New England, Great Lakes, and Mid East, which corresponds to the industrial traditional belt of U.S.) to the Sun Belt has taken place (that in this work is formed by California, Texas and Florida). Since the process can be discontinuous or to experience some alteration in the time, the possibility of detecting structural breaks in its evolution has been introduced.

The main results are three. First, the presence of a Regional Inversion type is accepted in eleven of the twenty analyzed industries. Consequently, it is a phenomenon whose existence is not solely theoretical but that it finds suitable representation in the real world. As well, the fact that it does not appear in all the sectors shows that the changes in the American industrial landscape have not affected all the industries in an homogenous way.

Secondly, it is in the sector of non-durable goods where it appears the process of Regional Inversion with more frequency; in particular, only in three of ten industries of non-durable does not take place. Thirdly, the introduction of structural breaks allows to deduce, in those sectors in which Regional Inversion occurs, that this process experiences a discontinuity in almost all the industries at the beginning of the eighty, being able to speak of a deceleration in this process, that is to say, a certain recovery of the old industrial belt of the North.

Finally, the methodology proposed and the concepts defined here can turn out useful to verify the existence of Regional Inversion in the economies of other developed countries, in addition to U.S.. This extension constitutes an investigation different and complementary to the presented in this work.

## 6.- References


Bernard, A.B. and S.N. Durlauf, (1995), “Convergence in International Output”, *Journal of Applied Econometrics*, vol. 10(2), pp. 97-108.

Bernard, A.B. and S.N. Durlauf, (1996), “Interpreting Tests of the Convergence Hypothesis”, *Journal of Econometrics*, vol. 71(1-2), pp. 161-73.

Blanchard, O.J. and L.F. Katz, (1992), “Regional Evolutions”, *Brookings Papers on Economic Activity*, vol. 1, pp. 1-61.

Bourne, L.S., “(1980), “Alternative Perspectives on Urban Declive and Population Deconcentration”, *Urban Geography*, vol. 1, pp. 39-52.

Chinitz, B., (1986), “The Regional Transformation of the American Economy”, *American Economic Review*, vol.76(2), pp. 300-303.

Dickey, D.A. and W.A. Fuller, (1979), “Distribution of the Estimator for Autoregressive Time Series with a Unit Root”, *Journal of the American Statistical Association*, vol. 74, pp.427-431.

Fan, C.C., E. Casetti, (1994), “The Spatial and Temporal Dynamics of U.S. Regional Income Inequality, 1950-1989”, *Annals of Regional Science*, vol. 28(2), pp. 177-196.

Fogel, R.W. and S.L. Engerman (eds.), (1971), *The Reinterpretation of American Economic History*, (New York: Harper an Row).

Fujita, M., P. Krugman, A.J. Venables, (1999), *The spatial economy: Cities, regions, and international trade*, (Cambridge and London: MIT Press).

Hayter, R., (1997), *The Dynamics of Industrial Location* (Wiley & Sons. Chichester, U.K.).

Kim, S., (1995), “Expansion of Markets and the Geographic Distribution of Economic Activities: The Trends in U.S. Regional Manufacturing Structure, 1860-1987”, *Quarterly Journal of Economics*, 110, 881-908.

Krugman, P. R., (1991), “Increasing Returns and Economic Geography”, *Journal of Political Economy*, vol. 99, pp. 483-499.

Ng. S. and P. Perron, (1995), “Unit Root Test in ARMA Models with Data-Dependent Methods for the Selection of the Truncation Lag”, *Journal of the American Statistical Association,* vol. 90, pp.268-281.

Norton, R.D., (1990), “Population Growth and U.S. Regional Futures”, *Survey of Regional Literature,* vol. 16, pp. 2-14.

Perron, P., (1989), “The Great Crash, the Oil Shock and the Unit Root Hypothesis”, *Econometrica,* vol. 57, pp. 1361-1402.

Puga, D., (1999), “The Rise and Fall of Regional Inequalities”, *European Economic Review,* vol. 43, pp. 303-334.

Quah, D.T., (1996), “Regional Convergence Clusters across Europe”, *European Economic Review*, 40, 951-958.

Rowley, T.D., J.M. Redman, J. Angle, (1991), “The Rapid Rise in State Per Capita Income Inequality in the 1980’s: Sources and Prospects”, U.S. Department of Agriculture, Staff Report AGES 9104.

Stevens B.H. and G.I. Treyz, (1986), “A Multiregional Model Forecast for the United States through 1995”, *American Economic Review,* 76(2), 304-307.

Stutz, F. P. and A. R. de Souza, (1998), *The World Economy, Resources, Location, Trade, and Development.* (Prentice-Hall).

Suarez-Villa, L., (1989), “Policentric Restructuring, Metropolitan Evolution, and the Decentralization of Manufacturing”, *Tijdschrift voor Econ. En Soc. Geografie,* vol. 80(4), pp. 194-205.

Suarez-Villa, L., (1992), “Tentieth century U.S. Regional and Sectoral Change in Perspective”, *Survey of Regional Literature,* 20, 32-39

Suarez-Villa L. and J. R. Cuadrado Roura, (1993), “Regional Economic Integration and the Evolution of Disparities”, *Papers in Regional Science,* 72, 369-387.

Vogelsang, T and P. Perron, (1998), “Additional Tests for a Unit Root Allowing for a Break in the Trend Function at Unknown Time”, *International Economic Review,* 39, 1073-1100.

Table 1. Testing for unit roots.

| Sector | ADF |
|---|---|
| 20 | -2.36 |
| 21 | -2.90 |
| 22 | -2.02 |
| 23 | -3.14 |
| 24 | -2.07 |
| 25 | -1.33 |
| 26 | -3.71[b] |
| 27 | 1.02 |
| 28 | -1.93 |
| 29 | -1.57 |
| 30 | -1.67 |
| 31 | -3.55[b] |
| 32 | -0.71 |
| 33 | -0.70 |
| 34 | -1.56 |
| 35 | -1.58 |
| 36 | -0.43 |
| 37 | -1.80 |
| 38 | -2.89 |
| 39 | -2.39 |

This Table reports the values of the Augmented Dickey-Fuller tests for studying the integration order of the ratio $\ln(FB_{i,t}/SB_{i,t})$, where $FB_{it}$ represents the percentage of employment in the Frost Belt for Sector i at period t, whilst $SB_{it}$ is the percentage of employment in the Sun Belt for Sector i at period t. The first column shows the different sectors under consideration, whilst the second reports the ADF tests. These statistics were calculated from the estimation of model (8), with the value of the lag truncation parameter being selected according to the k(t) method proposed in Ng and Perron (1995), with kmax=5..

Critical Values: -3.18, -3.50 and –4.15 (for a 10%, 5% and 1% significance level, respectively)

Table 2. Testing for unit roots under the presence of structural breaks

| Sector | $\max_{\gamma} t_{\hat{\alpha}}$ | TB |
|---|---|---|
| | Panel A. Mixed Change | |
| 20 | -6.24 | 1981 |
| 25 | -7.08 | 1981 |
| 28 | -5.13 | 1982 |
| 29 | -7.43 | 1980 |
| 30 | -6.26 | 1979 |
| 34 | -5.03 | 1984 |
| 35 | -6.77 | 1979 |
| 38 | -6.37 | 1986 |
| | Panel B. Change in the intercept | |
| Sector | $\max_{\delta} t_{\hat{\alpha}}$ | TB |
| 23 | -5.26 | 1980 |
| 26 | -5.08 | 1984 |
| 31 | -7.16 | 1980 |

This Table reports the values of the statistics for testing the unit root hypothesis under the presence of a break. Panel A considers the case where the break affects both the intercept and the slope of the model, whilst the results of Panel B are related to the case where the break exclusively affects the intercept. The statistics were obtained from the estimation of models [9], Panel A, and [10], Panel B. The time of the break has been chosen by maximizing the t-ratio associated to the parameters γ and δ, respectively for Panels A and B.

Critical Values. Panel A: -4.47, -4.91 and –5.56 for a 10%, 5% and 1% significance level, respectively. Panel B: -4.50, -4.83 and –5.43 for a 10%, 5% and 1% significance level, respectively.

a, b and c signifies rejection of the unit root hypothesis for a 1%, 5% and 10% significance level, respectively.

**Figure 1. Partial Regional Inversion.**

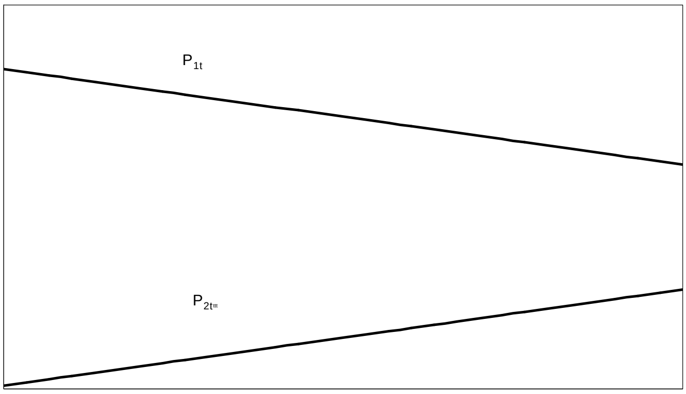



**Figure 2. Strong Regional Inversion.**

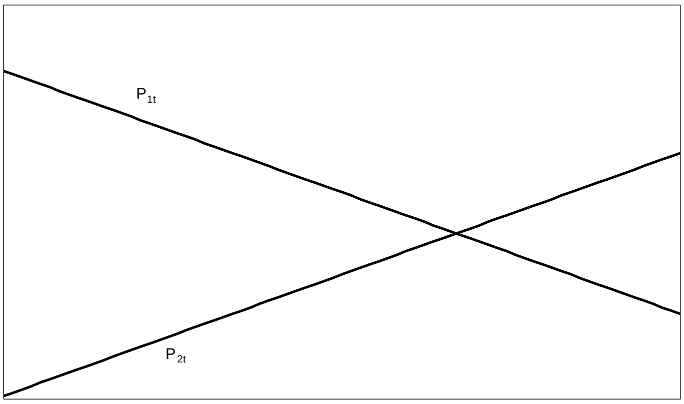



Figure 3. Absolute Regional Inversion.

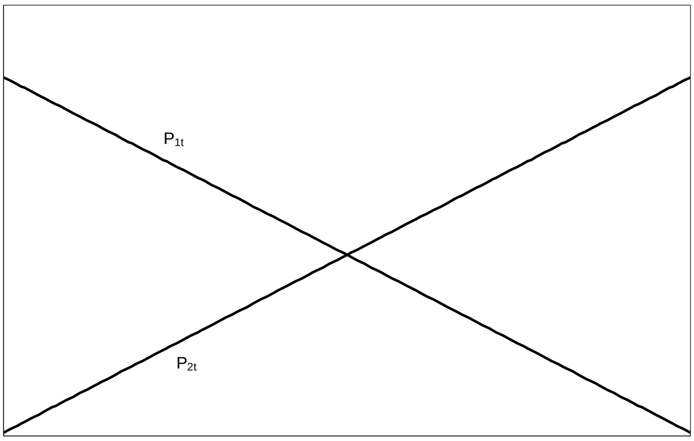
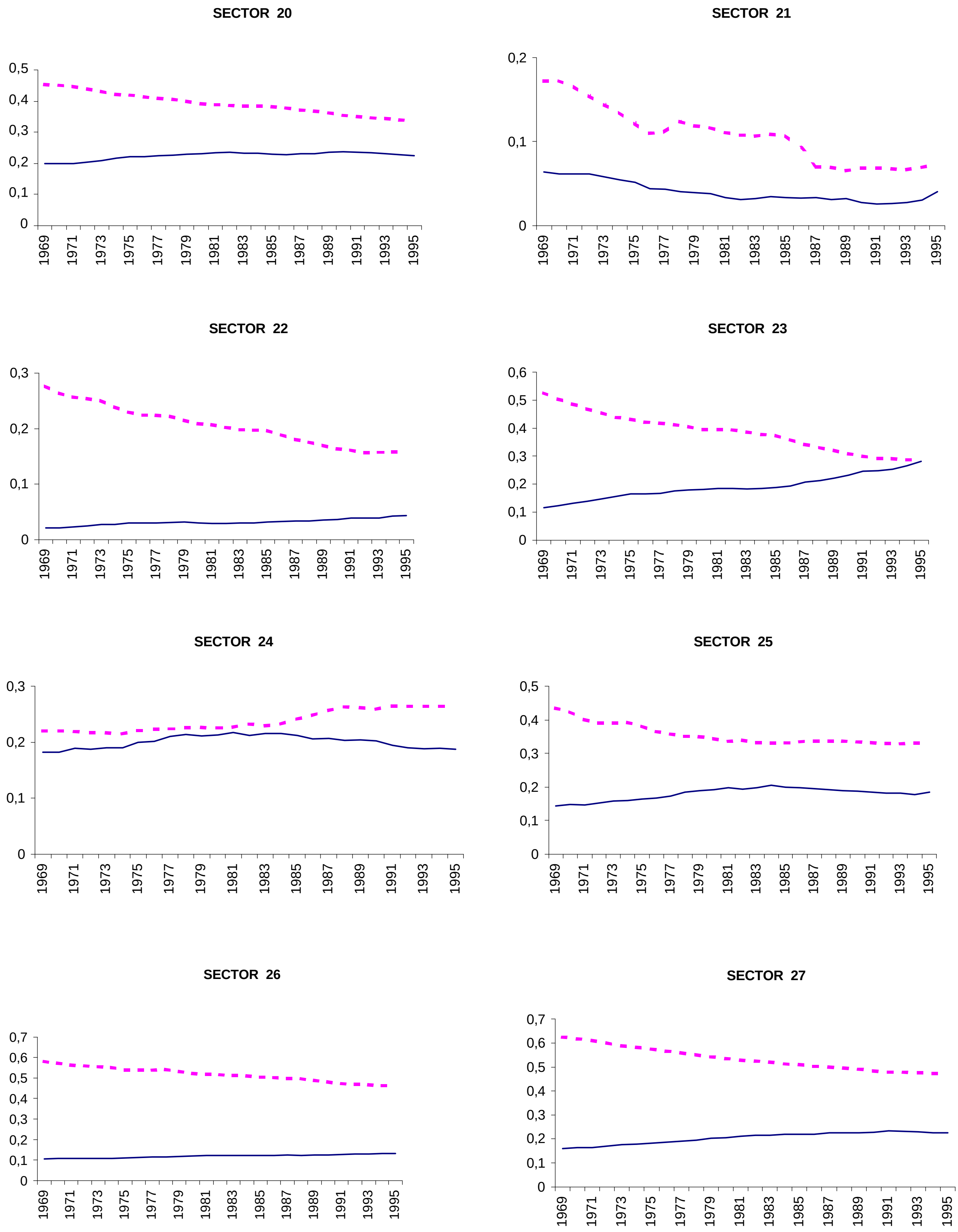
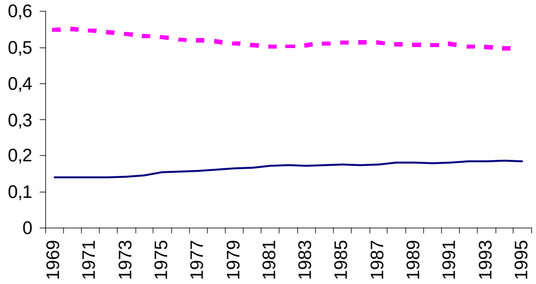


Figure 4. Evolution of the percentage of employment in the US manufacture sectors. The dotted line reflects the Frost Belt, whilst the straight line represents the Sun Belt.



**SECTOR 28**

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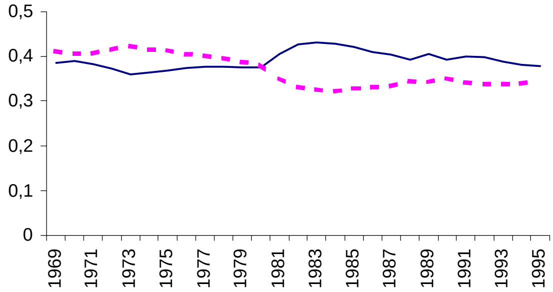


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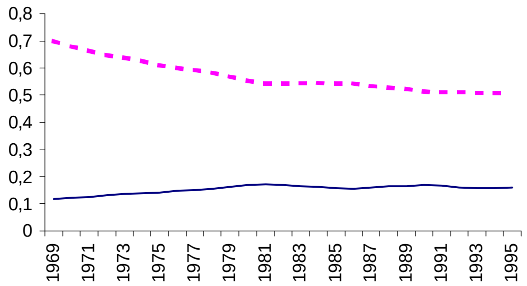
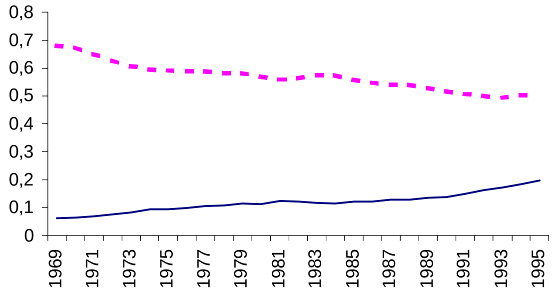



**SECTOR 31**

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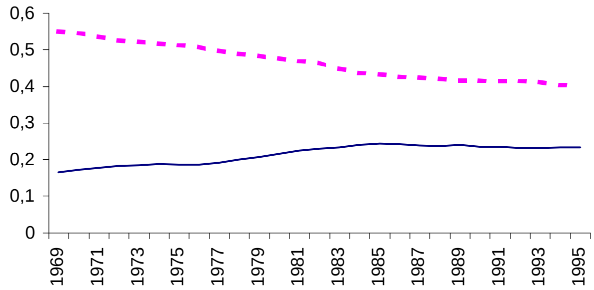


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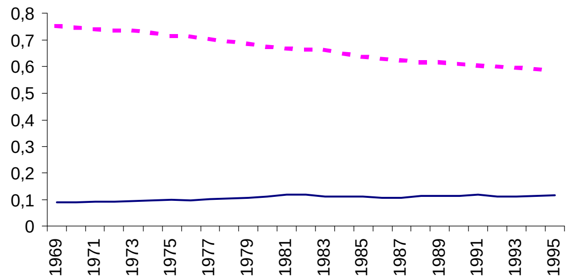


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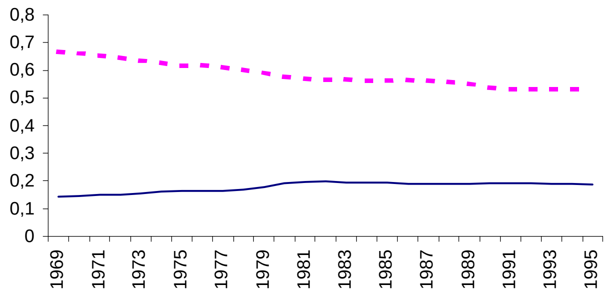


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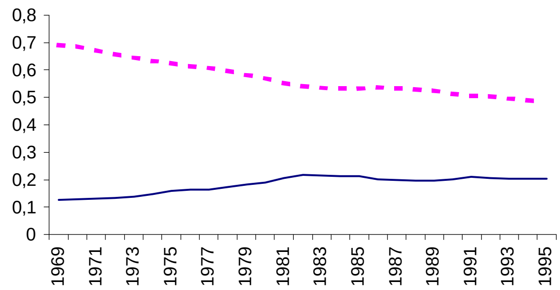

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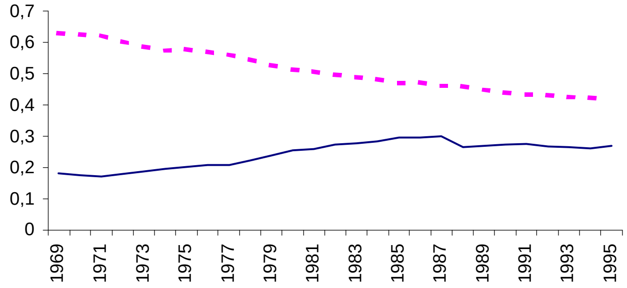


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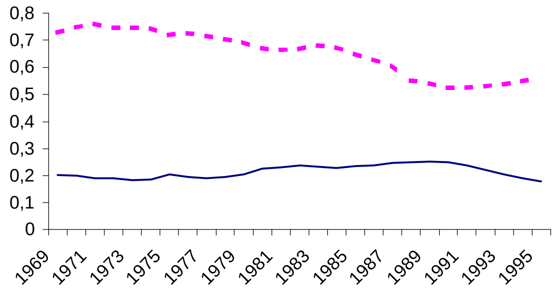


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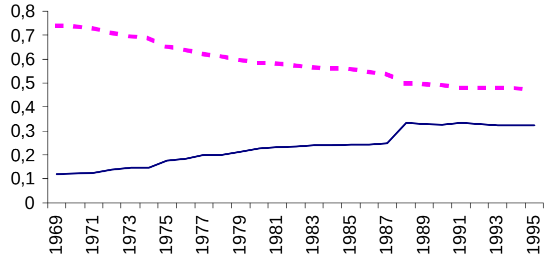


SECTOR 39